

Dynamic Real-Time Deformations

using

Space & Time Adaptive Sampling

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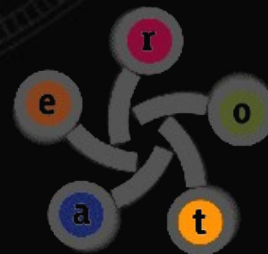
Marie-Paule

Alan H. Barr

Cani



iMAGIS



Motivation : surgery simulation



© Epidaure

Consequences

Only ~100 nodes for volume sampling

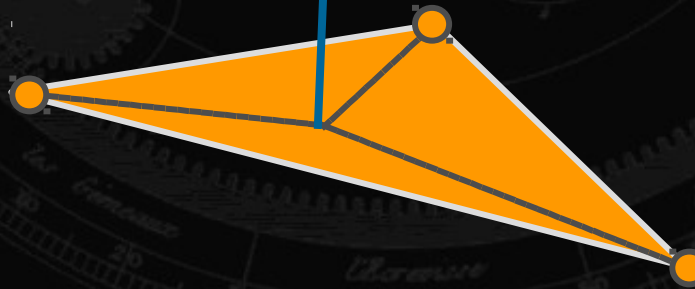
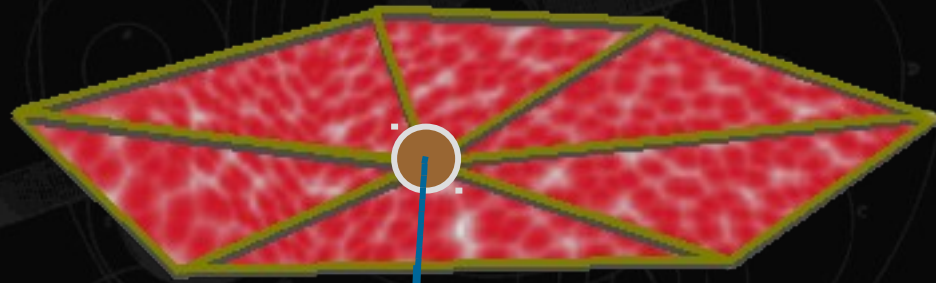
→ Optimal placement of samples required

Separate surface and internal 3D model

→ Must be linked

How to link with the surface

Displayed surface



Internal physical model

Challenges



Locally adapt sampling:

- When ? Where ? How ?

Find a physical model:

- Dynamic behavior independent of discretization

Overview

- Multiresolution animation
- Choice of a physical model
- Results

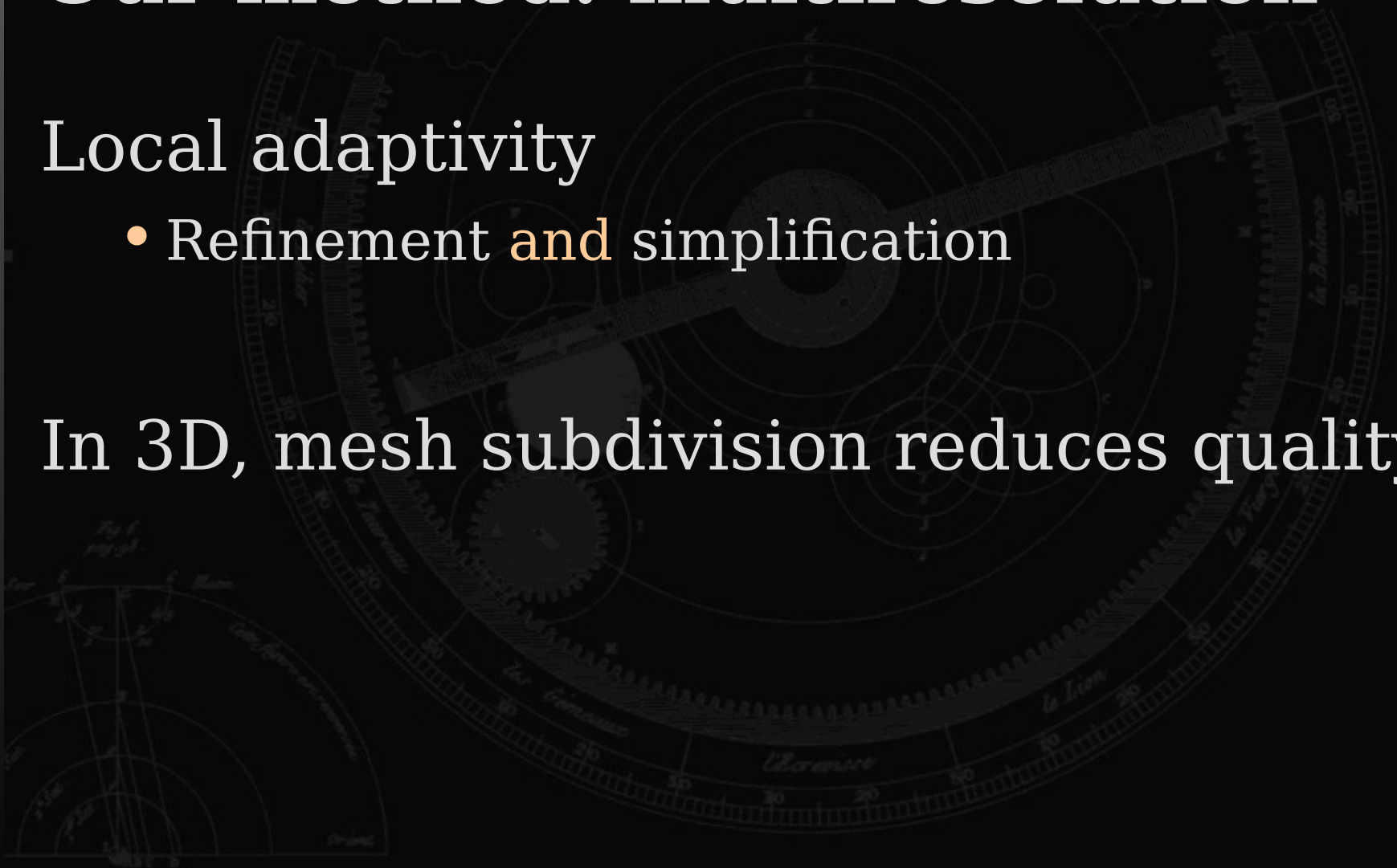


Our method: multiresolution

Local adaptivity

- Refinement **and** simplification

In 3D, mesh subdivision reduces quality

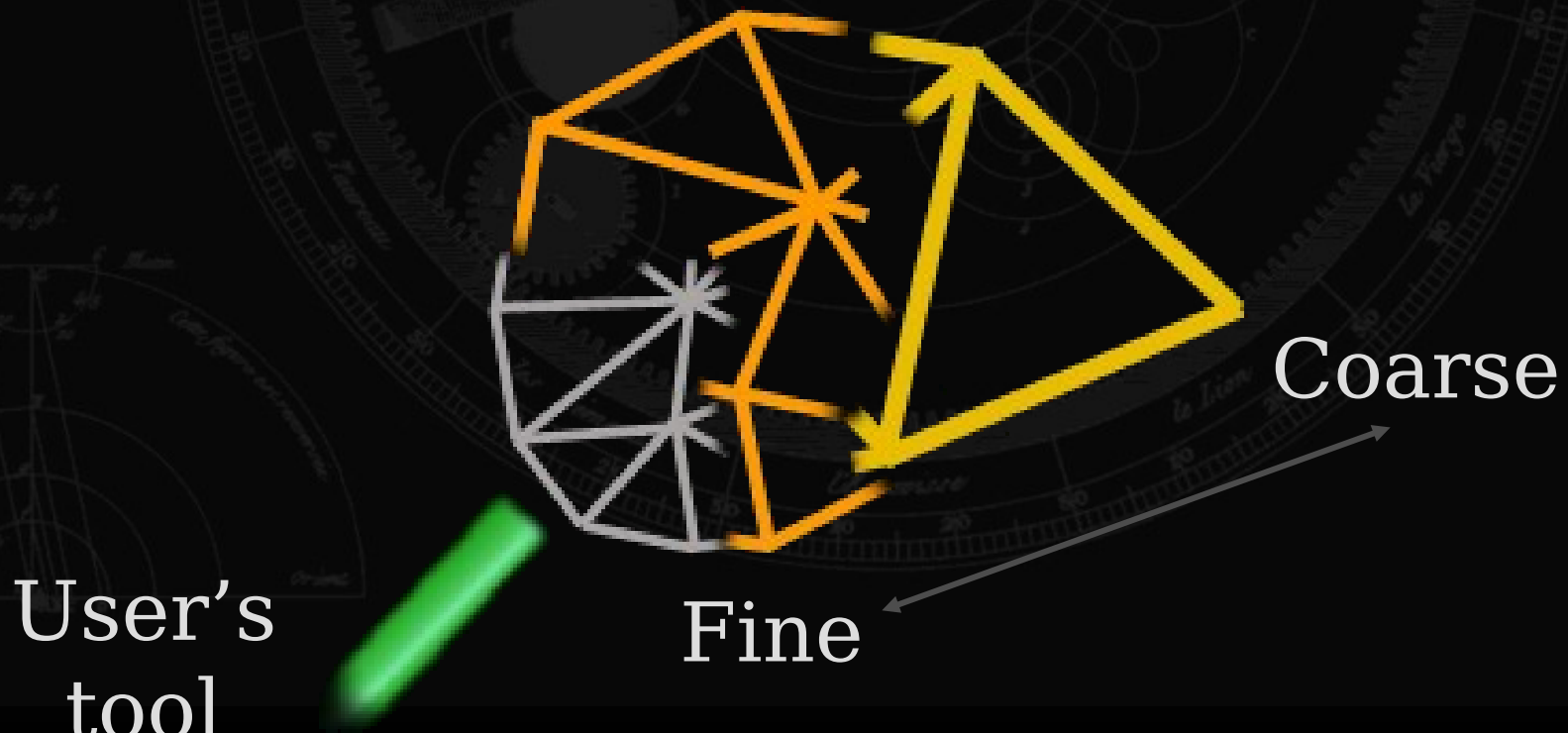


Meshes of the object

Made of tetrahedra

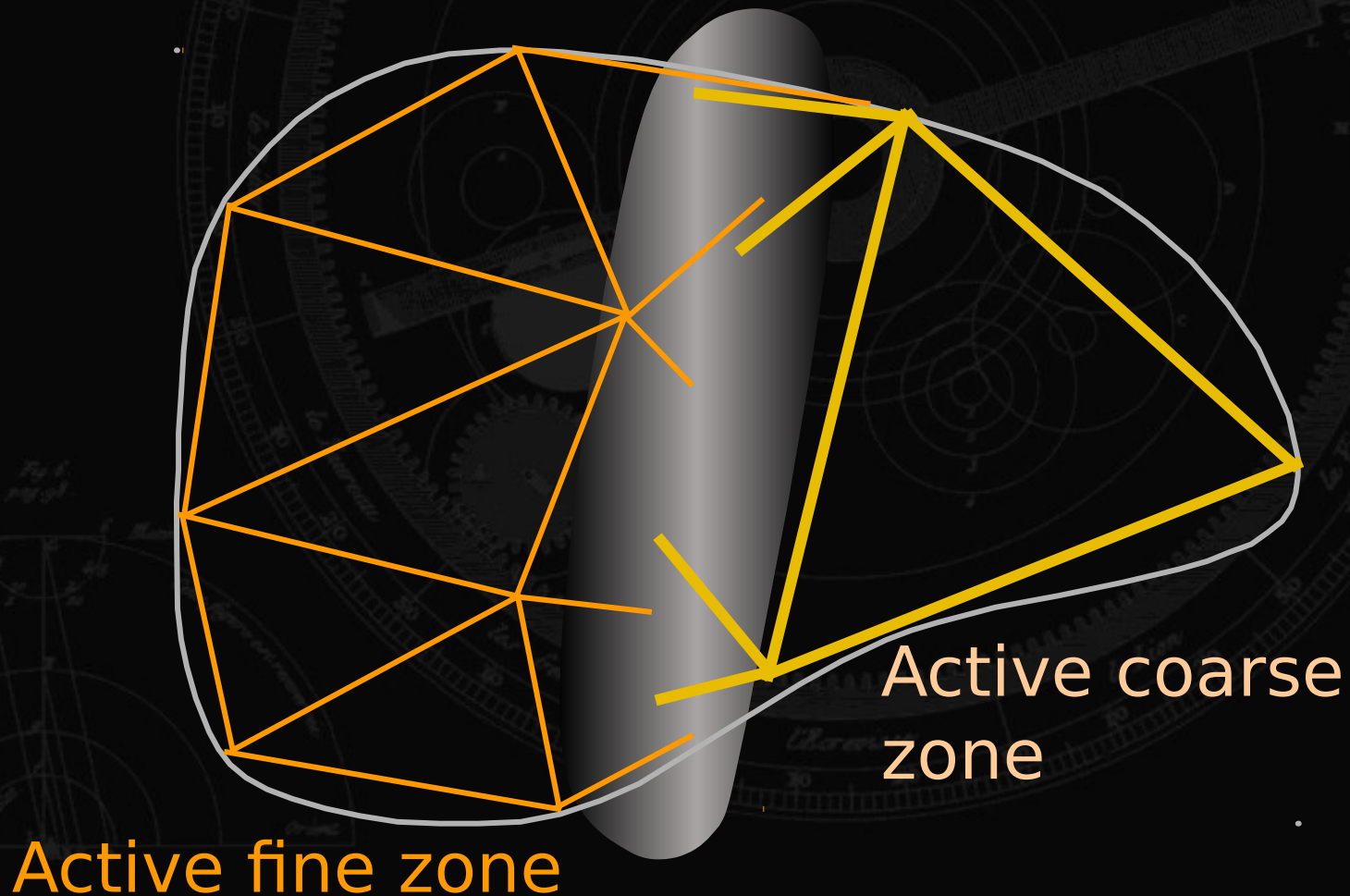
Independent from each other

Optimized quality

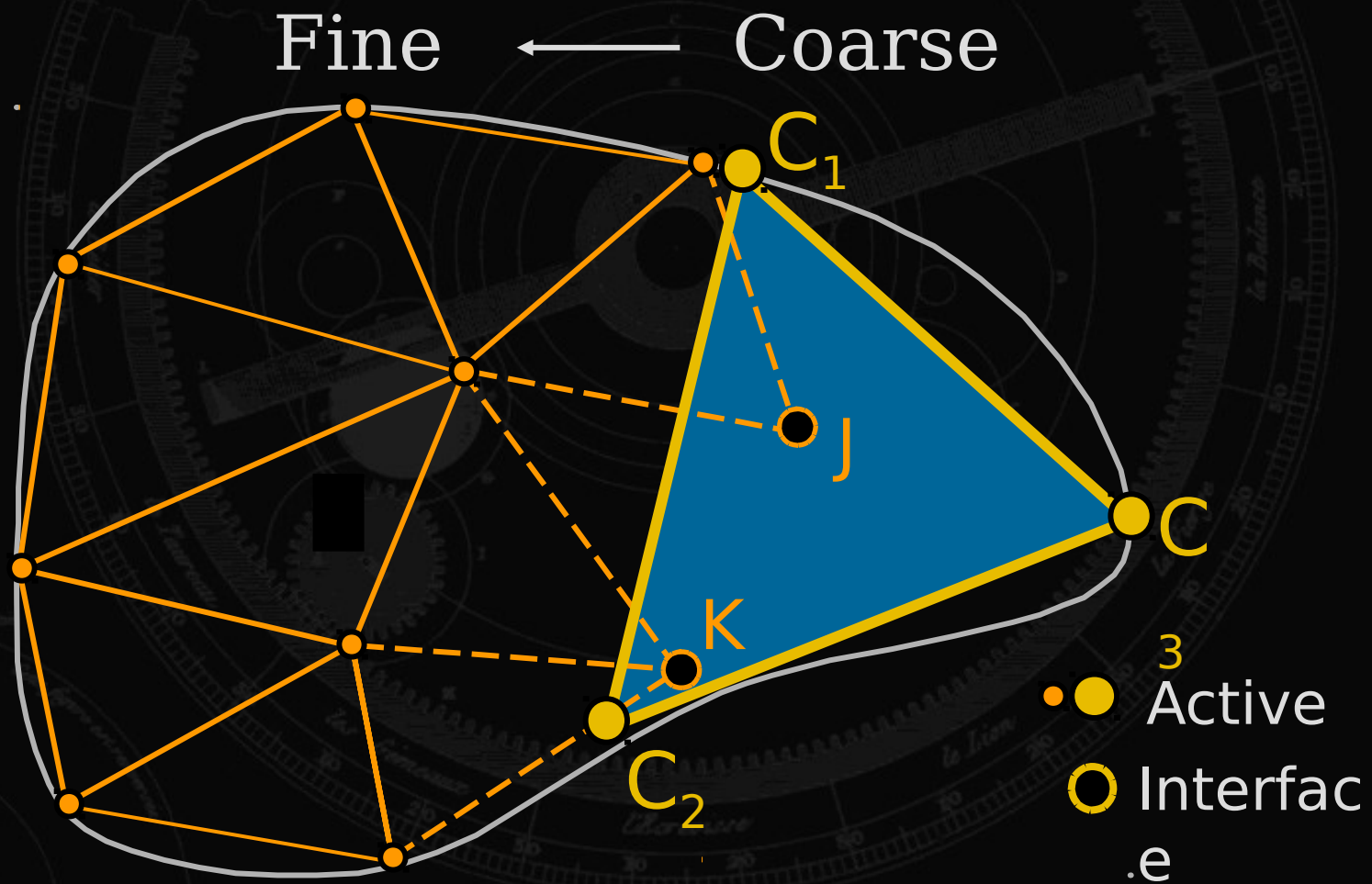


Interface between meshes

Interface zone



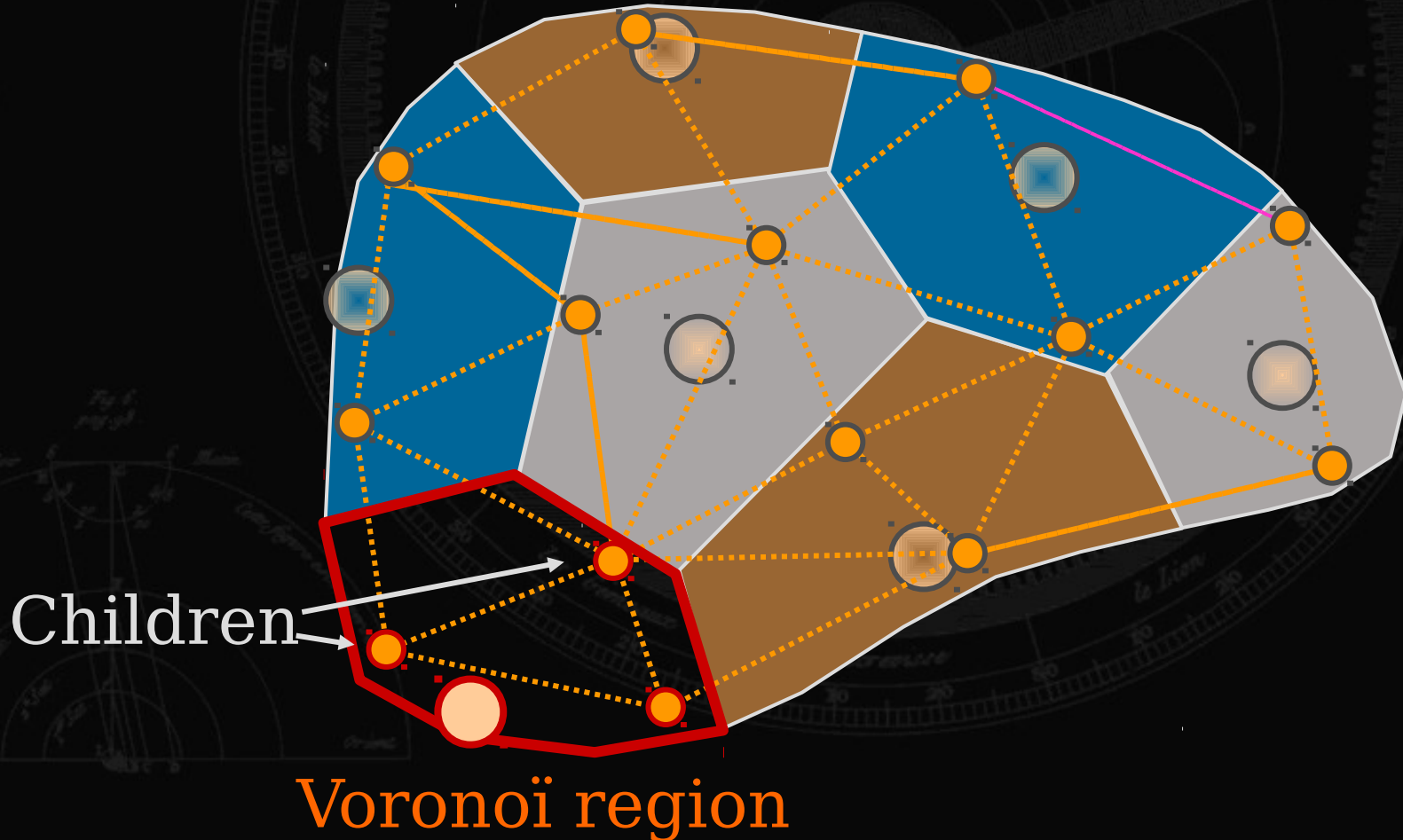




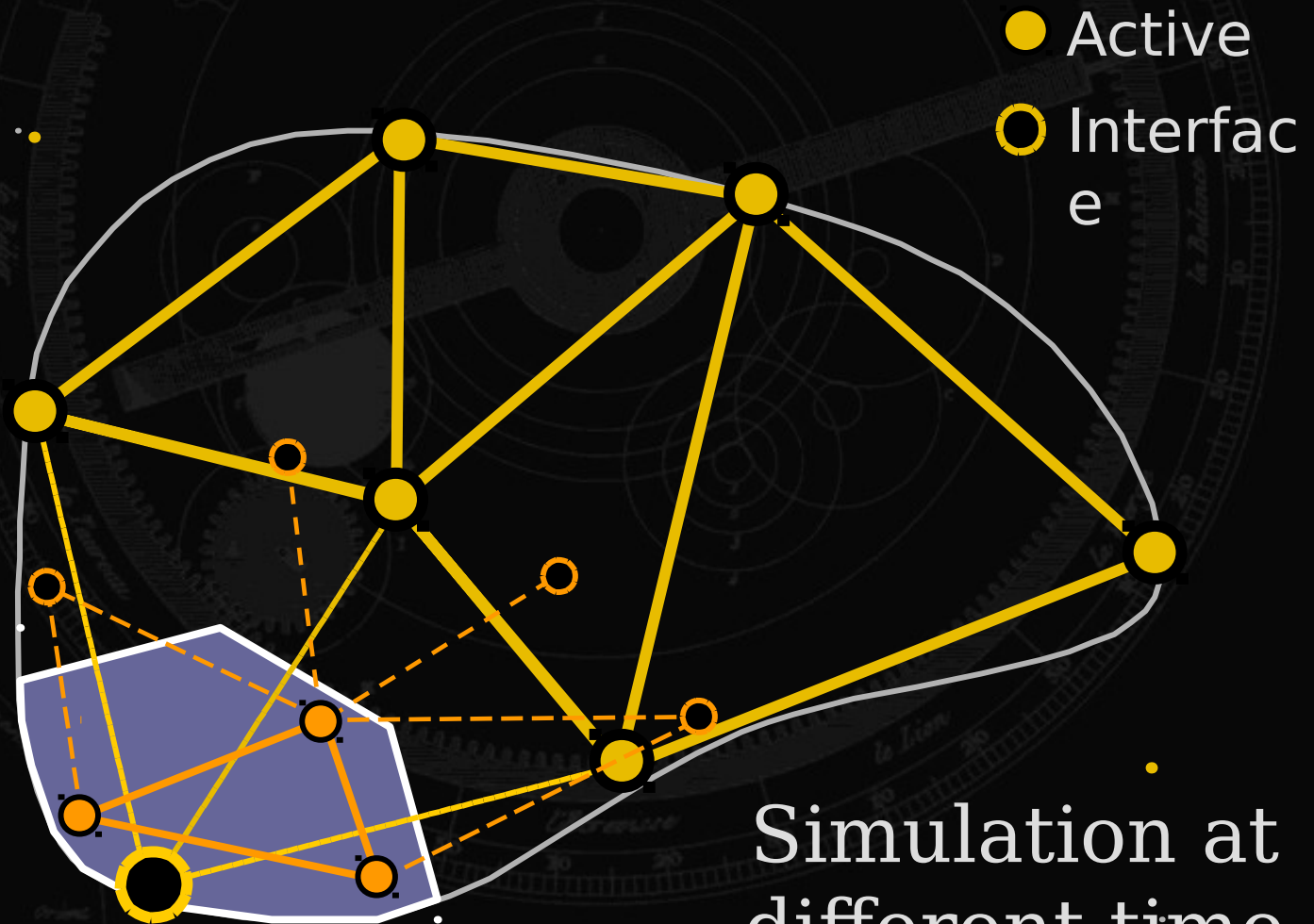
J, K interpolated from $C_1 C_2 C_3$

Definition of children

Precomputed hierarchy



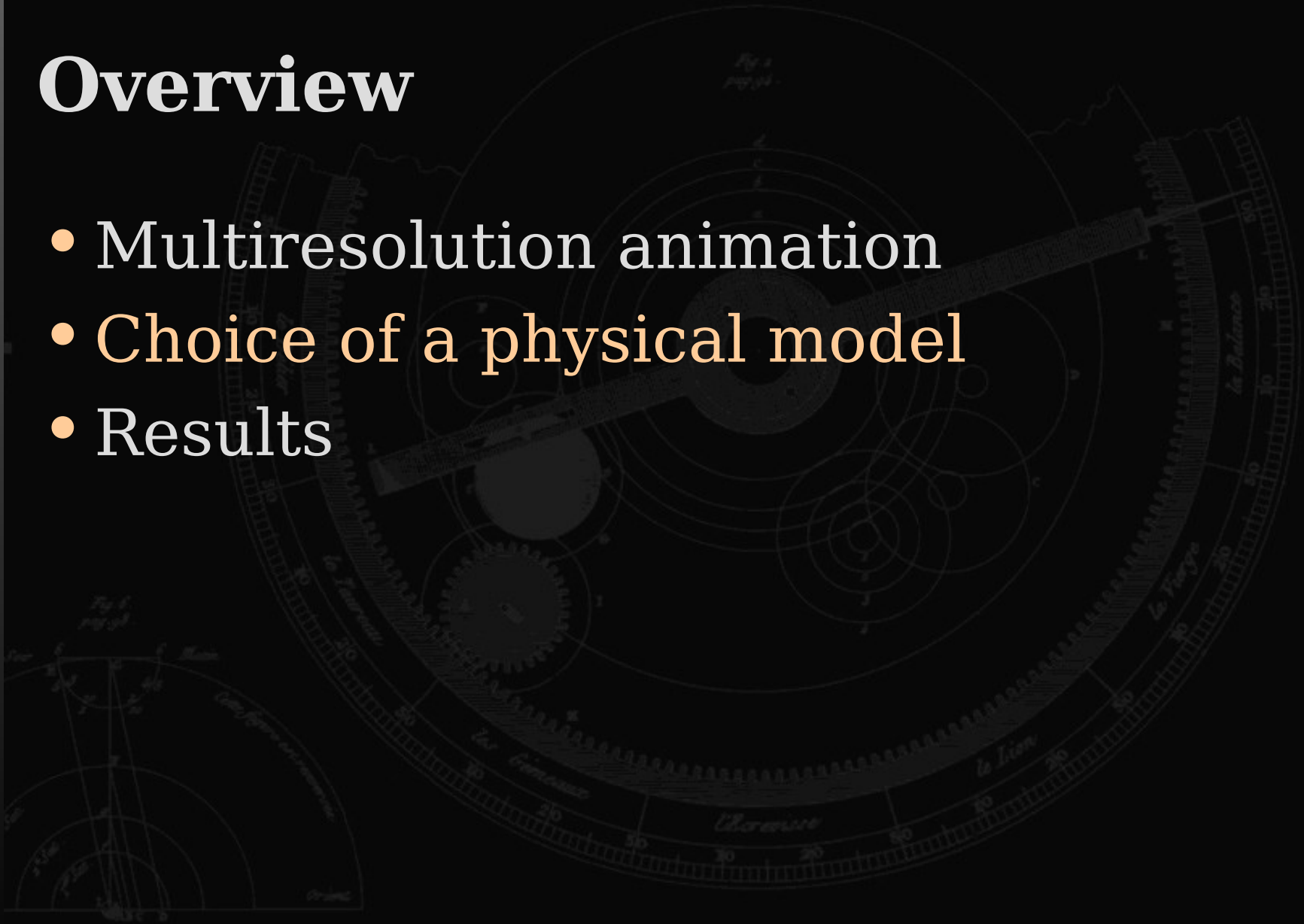
Resulting mesh structure



Simulation at
different time
steps

Overview

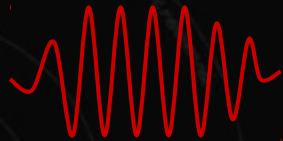
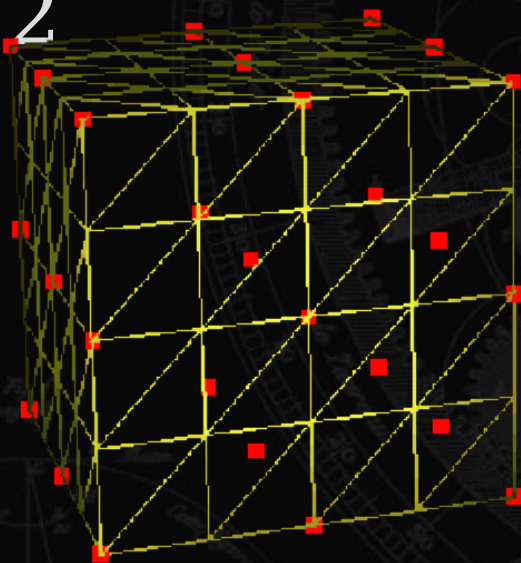
- Multiresolution animation
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Different discretizations

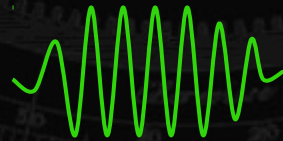
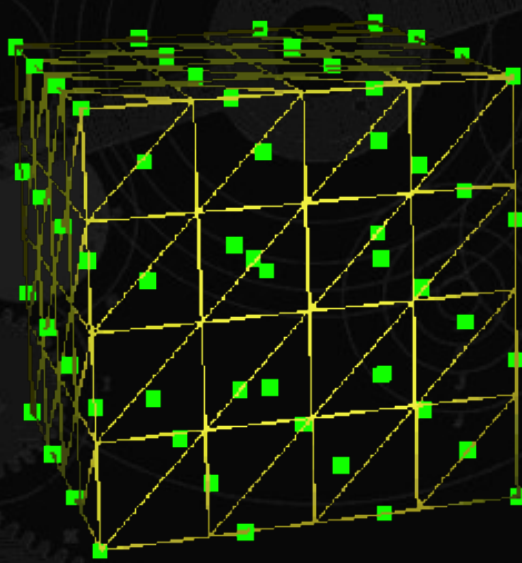
Level 0

2



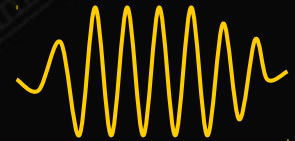
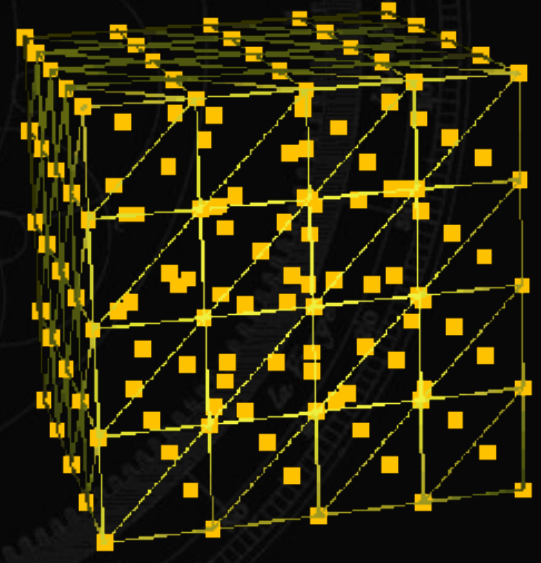
3^3 points

Level 1



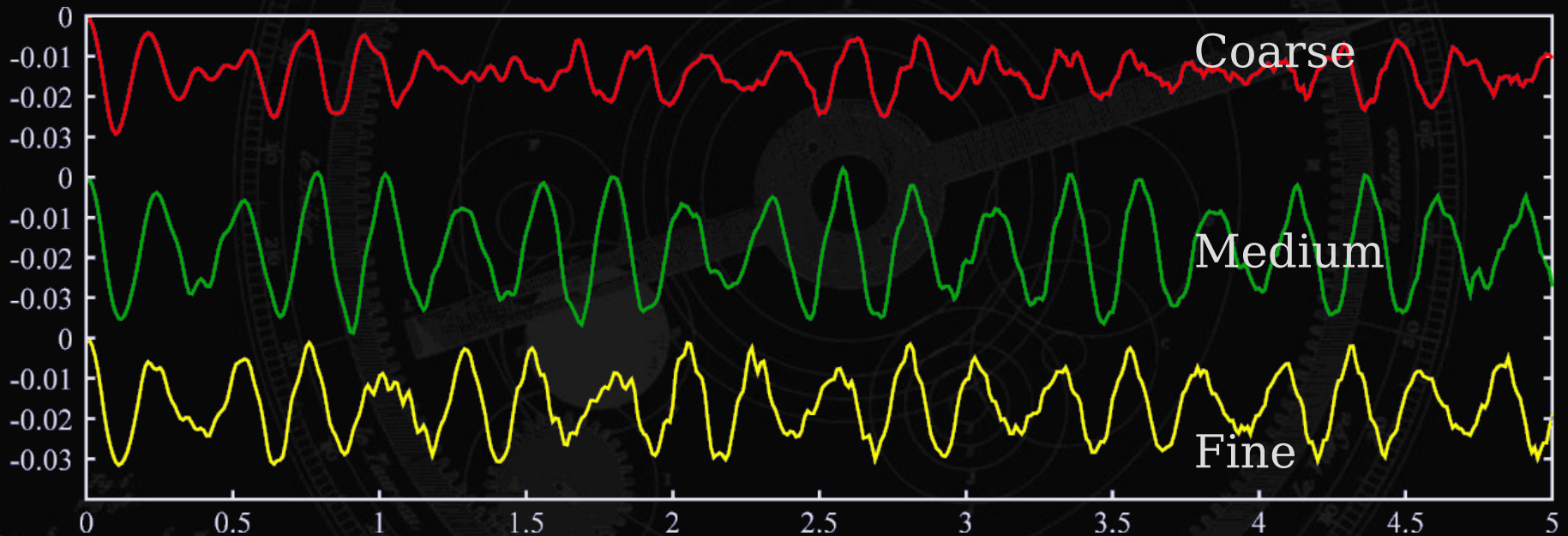
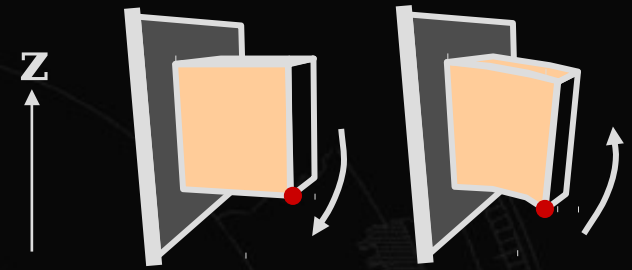
4^3 points

Level



5^3 points

Mass-spring system



« As close as possible » to Finite Elements [Gel98]

- Amplitude varies
- No smoothness

Classical Finite Elements

+ Accuracy
Speed

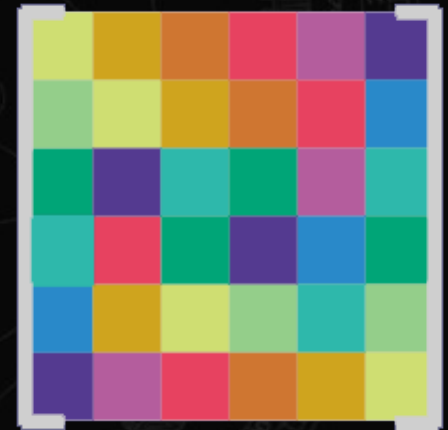
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Object

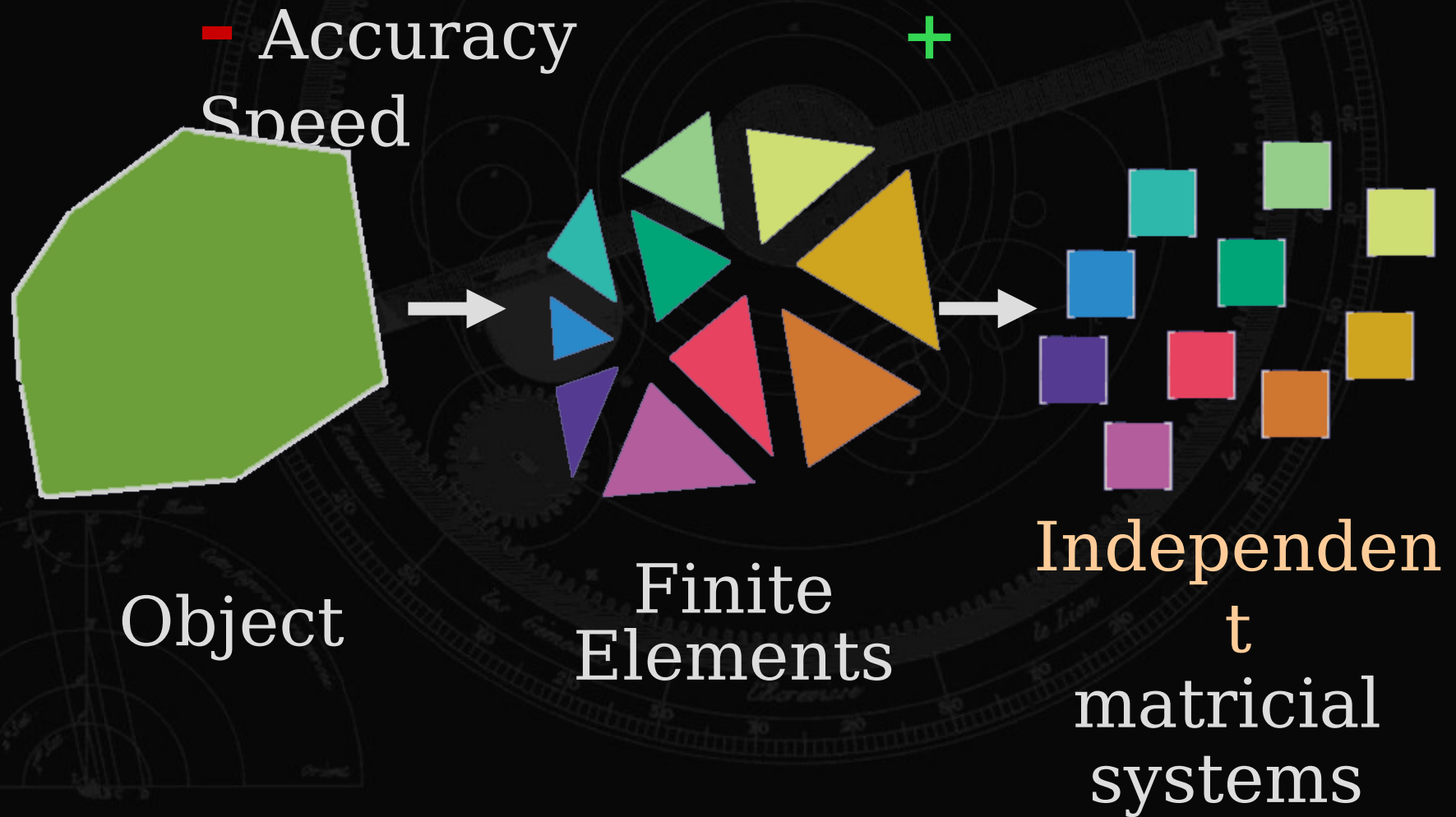


Finite
Elements

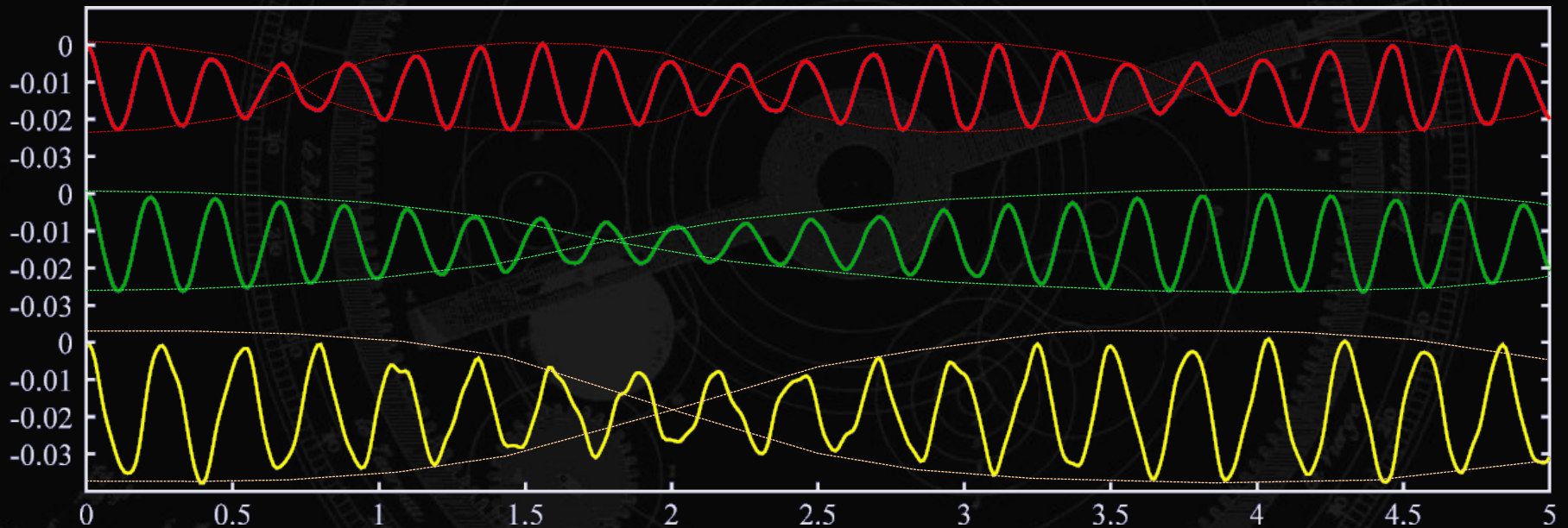


Large
matrixial
system

Explicit Finite Elements



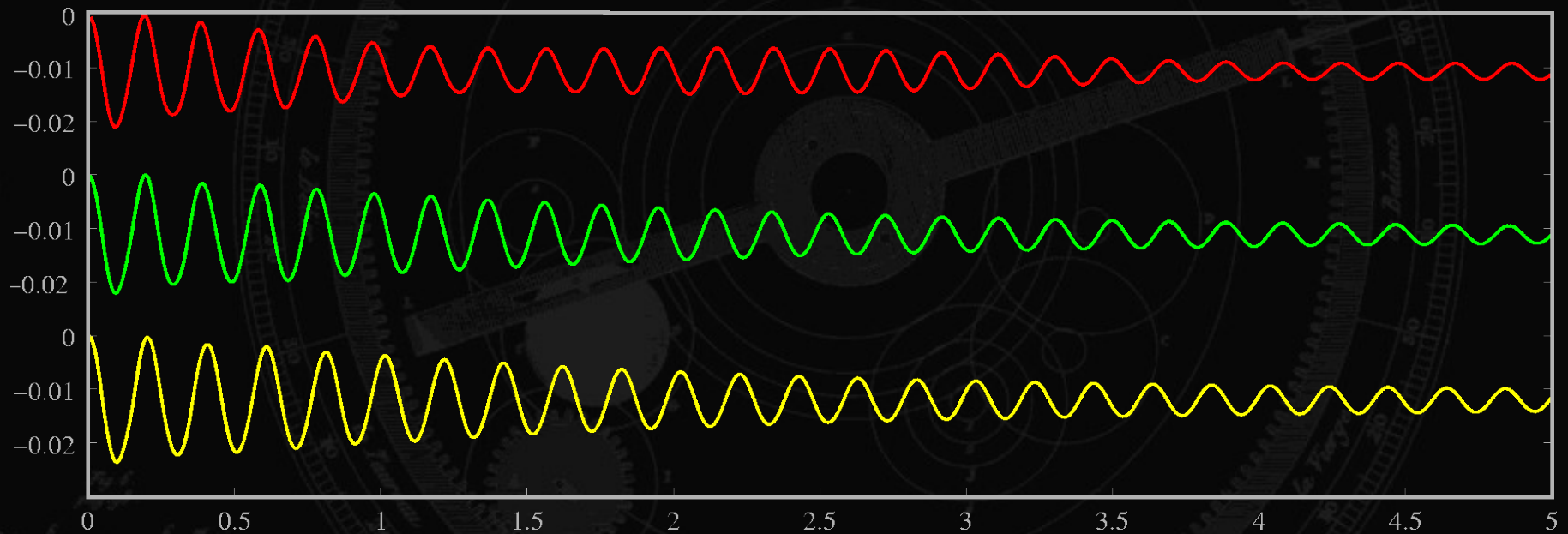
Cauchy tensor



Mass-tensor [Cot97]

Oscillations of the amplitude

With Rayleigh damping



Multiresolution is preserved

Real-Time simulation

Computation and display are synchronized

$1/30^{\text{th}}$ sec, time experienced by the user

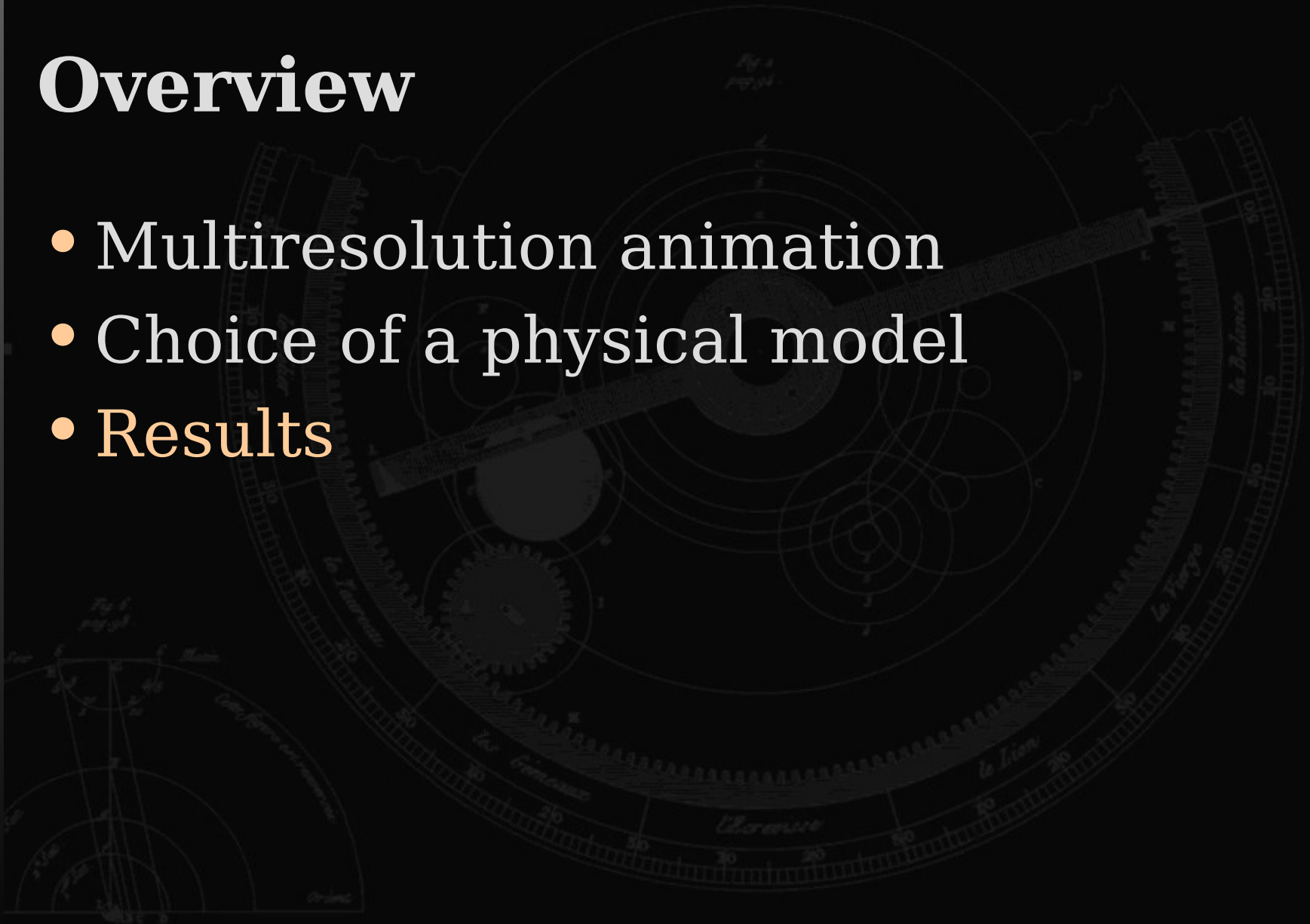


$1/30^{\text{th}}$ sec simulated time

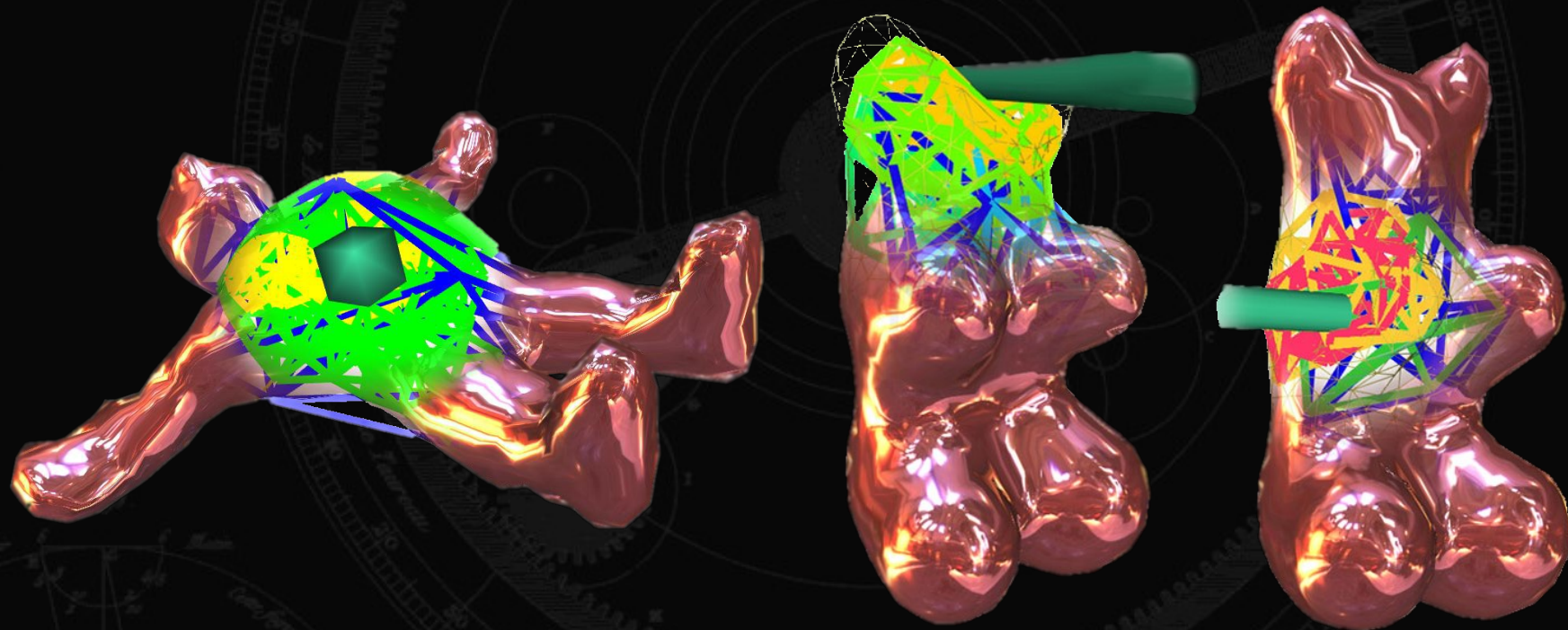
Force feedback
1000Hz

Overview

- Multiresolution animation
- Choice of a physical model
- Results



Video



Perspectives

Hierarchical collision detection

Cuts of the object

Validation by surgeon



The surgeon robot

Serre

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SIGGRAPH

2001 EXPLORE INTERACTION
AND DIGITAL IMAGES

